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(54) **COLLIMATOR FOR OPTICAL PICK-UP UNITS**

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(22) Filed: **Jun. 13, 2012**

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(51) **Int. Cl.**
***G11B 7/1374*** (2012.01)
***G11B 7/1376*** (2012.01)

(52) **U.S. Cl.**
USPC ..... **369/112.23**

(58) **Field of Classification Search**
USPC ..... 369/44.29, 47.38, 94, 112.23, 112.03, 369/112.01
See application file for complete search history.

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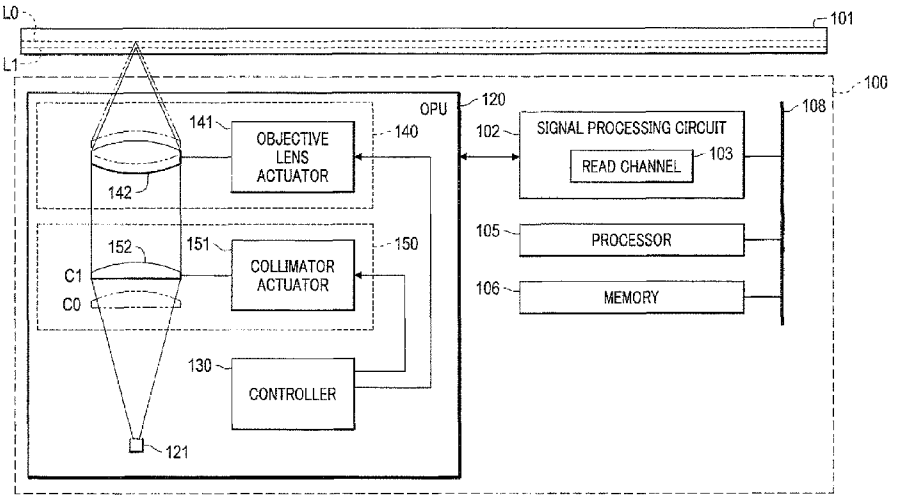
(57) **ABSTRACT**

Aspects of the disclosure provide an apparatus. The apparatus includes a collimator configured to have a plurality of positions, and a controller configured to control the collimator to move to a predetermined position associated with a data layer of an optical storage medium to collimate a light beam. The collimated light beam is then focused onto the data layer of the optical storage medium.

**18 Claims, 4 Drawing Sheets**



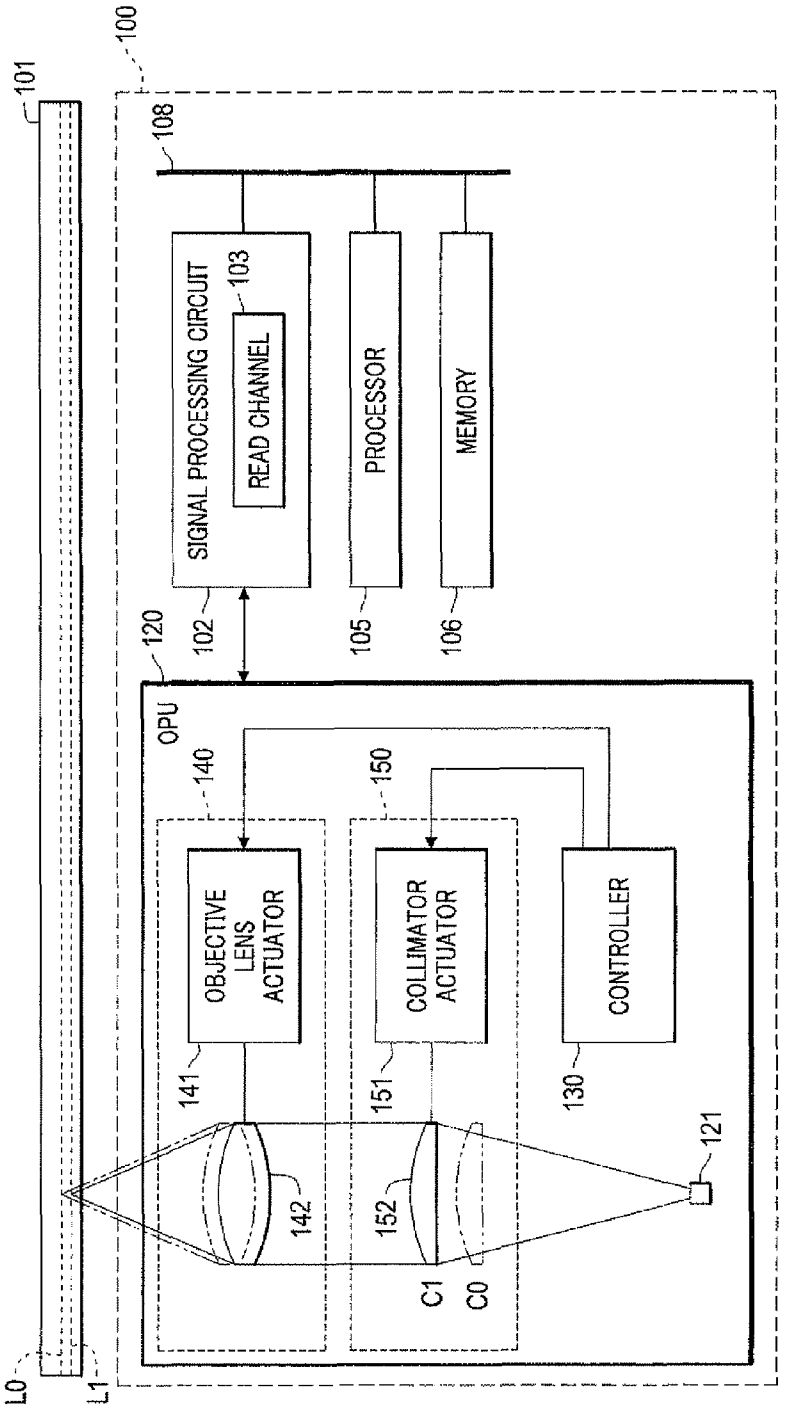

100
101
108
SIGNAL PROCESSING CIRCUIT
103
READ CHANNEL
PROCESSOR
MEMORY
102
105
106
120
OPU
140
150
OBJECTIVE LENS ACTUATOR
COLLIMATOR ACTUATOR
CONTROLLER
141
151
130
121
142
152
C1
C0
L0
L1

FIG. 1

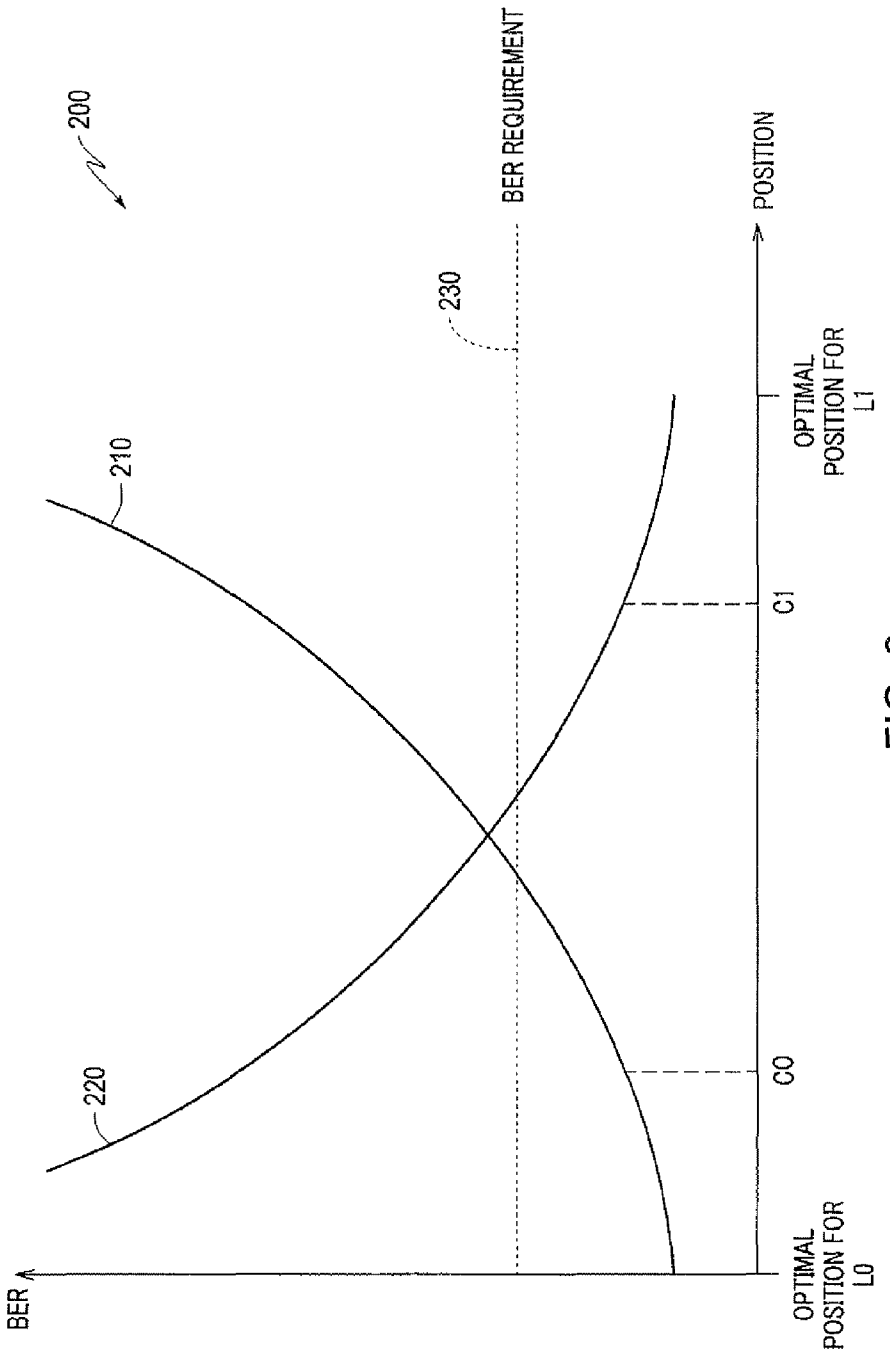

200
BER REQUIREMENT
230
POSITION
210
OPTIMAL POSITION FOR L1
C1
220
C0
BER
OPTIMAL POSITION FOR L0

FIG. 2

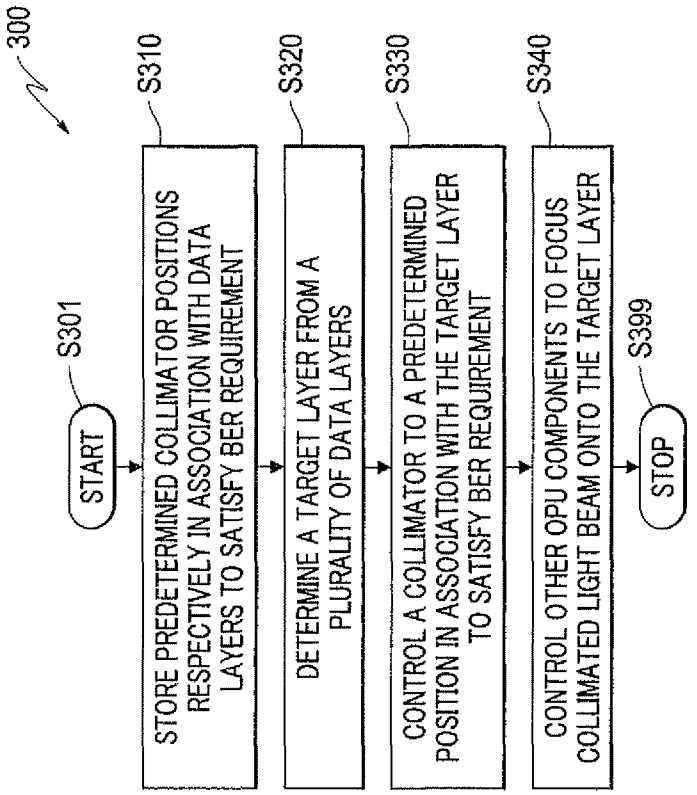

300
START
S301
STORE PREDETERMINED COLLIMATOR POSITIONS RESPECTIVELY IN ASSOCIATION WITH DATA LAYERS TO SATISFY BER REQUIREMENT
S310
DETERMINE A TARGET LAYER FROM A PLURALITY OF DATA LAYERS
S320
CONTROL A COLLIMATOR TO A PREDETERMINED POSITION IN ASSOCIATION WITH THE TARGET LAYER TO SATISFY BER REQUIREMENT
S330
CONTROL OTHER OPU COMPONENTS TO FOCUS COLLIMATED LIGHT BEAM ONTO THE TARGET LAYER
S340
STOP
S399

FIG. 3

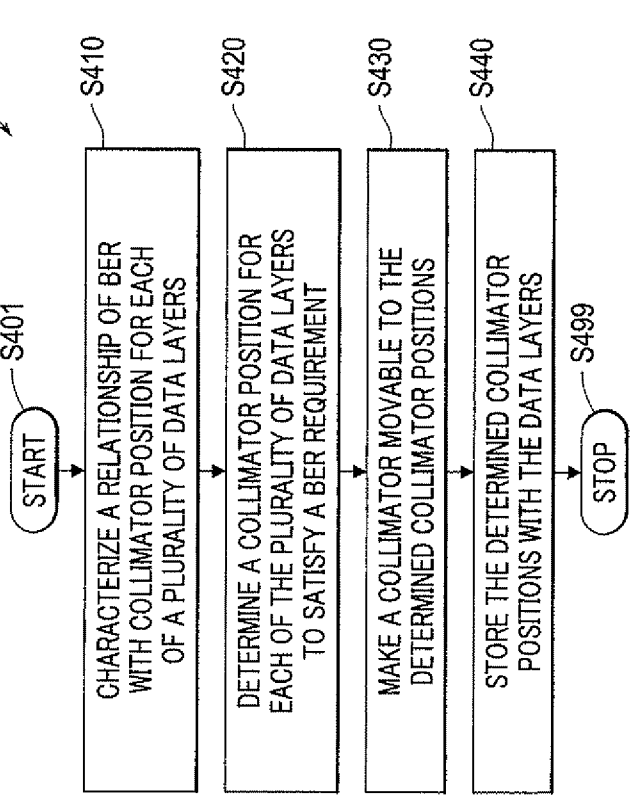

400
S401
START
S410
CHARACTERIZE A RELATIONSHIP OF BER WITH COLLIMATOR POSITION FOR EACH OF A PLURALITY OF DATA LAYERS
S420
DETERMINE A COLLIMATOR POSITION FOR EACH OF THE PLURALITY OF DATA LAYERS TO SATISFY A BER REQUIREMENT
S430
MAKE A COLLIMATOR MOVABLE TO THE DETERMINED COLLIMATOR POSITIONS
S440
STORE THE DETERMINED COLLIMATOR POSITIONS WITH THE DATA LAYERS
S499
STOP

FIG. 4

# COLLIMATOR FOR OPTICAL PICK-UP UNITS

## RELATED CASES

This present disclosure claims the benefit of U.S. Provisional Application No. 61/509,016, "Discrete Level Collimator for Optical Pick-Up Units," filed on Jul. 18, 2011, which is incorporated herein by reference in its entirety.

## BACKGROUND

The background description provided herein is for the purpose of generally presenting the context of the disclosure. Work of the presently named inventors, to the extent the work is described in this background section, as well as aspects of the description that may not otherwise qualify as prior art at the time of filing, are neither expressly nor impliedly admitted as prior art against the present disclosure.

Generally, an optical pickup unit (OPU) includes a collimator to collimate a light beam emitted from a light source. Further, the OPU includes an objective lens to focus the collimated light beam onto an optical disc.

## SUMMARY

Aspects of the disclosure provide an apparatus. The apparatus includes a collimator configured to have a plurality of positions, and a controller configured to control the collimator to move to a first predetermined position associated with a first data layer of an optical storage medium to collimate a light beam. The collimated light beam is focused onto the first data layer of the optical storage medium.

Further, in an embodiment, the controller is configured to control the collimator to move to a second predetermined position associated with a second data layer of the optical storage medium to collimate the light beam. The collimated light beam is then focused onto the second data layer of the optical storage medium.

According to an aspect of the disclosure, the apparatus includes a collimator moving module configured to move the collimator to one of the plurality of positions responsive to a control signal from the controller. The collimator moving module includes at least one of memory metals, coils, and actuators.

In an embodiment, the first predetermined position associated with the first data layer of the optical storage medium is predetermined based on an error rate requirement, such as a bit-error-rate (BER) requirement.

Aspects of the disclosure provide a method. The method includes determining a target layer from a plurality of data layers of an optical storage medium, moving a collimator to a predetermined position associated with the target layer, adjusting an objective lens to focus the collimated light beam onto the target layer of the optical disc. In an example, the position is predetermined for the target layer to satisfy an error rate requirement. Further, the method includes storing a plurality of predetermined positions associated with the plurality of data layers.

Aspects of the disclosure provide another method. The method includes predetermining a plurality of collimator positions associated with a plurality of data layers of an optical storage medium to satisfy an error rate requirement, and enabling a collimator moving module to move a collimator to the plurality of predetermined collimator positions. In an example, the method includes characterizing a relationship of error rate and collimator position for each of the plurality of data layers, and predetermining the collimator positions associated with the data layers based on relationships of error rate with collimator position.

Aspects of the disclosure provide an electronic system. The electronic system includes an optical pick-up unit (OPU). The OPU includes a collimator configured to have a plurality of positions, and a controller configured to control the collimator to move to a predetermined position associated with a data layer of an optical storage medium to collimate a light beam. The OPU further includes an objective lens configured to focus the collimated light beam onto the data layer.



## BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments of this disclosure that are proposed as examples will be described in detail with reference to the following figures, wherein like numerals reference like elements, and wherein:

FIG. **1** shows an electronic system **100** according to an embodiment of the disclosure;

FIG. **2** shows a plot **200** of bit-error-rate (BER) characteristics with regard to the collimator position;

FIG. **3** shows a flow chart outlining a process example **300** according to an embodiment of the disclosure; and

FIG. **4** shows a flow chart outlining a process example **400** according to an embodiment of the disclosure.

## DETAILED DESCRIPTION OF EMBODIMENTS

FIG. **1** shows an electronic system **100** and an optical storage medium **101** according to an embodiment of the disclosure. The electronic system **100** includes an optical pickup unit (OPU) **120** optically coupled with the optical storage medium **101** to operate on the optical storage medium **101**. The OPU **120** includes a collimator **152** that is movable to a plurality of predetermined positions for collimating a light beam. The electronic system **100** includes other suitable components, such as a signal processing circuit **102**, a processor **105**, a solid-state memory **106**, and the like. These elements are coupled together, for example, via a bus **108**, as shown in FIG. **1**.

According to an aspect of the disclosure, the optical storage medium **101** is a suitable disc, such as compact disc (CD), digital versatile disc (DVD), Blu-ray disc, and the like, that uses optical property changes to store information. In an embodiment, the optical storage medium **101** includes multiple data layers that are respectively used to store information. In the FIG. **1** example, the optical storage medium **101** includes two data layers, shown as a first layer L**1** and a second layer L**0**, which are used to store information. The first layer L**1** and the second layer L**0** are stacked with other suitable layers, such as a cover layer from which optical beams enter the optical storage medium **101**, a spacer layer between the first layer L**1** and the second layer L**0**, a substrate layer, and the like, to form the optical storage medium **101**. The thickness of the various layers may vary from disc to disc due to various variations during disc manufacturing, for example.

According to an aspect of the disclosure, the OPU **120** includes a light source **121**, a collimator module **150**, an objective lens module **140** and a controller **130**. The light source **121** generates a suitable light beam, such as a laser beam and the like. The controller **130** provides control signals to the collimator module **150** to collimate the light beam and provides control signals to the objective lens module **140** to focus the collimated light beam onto a data layer of the optical storage medium **101**, for example. It is noted that the OPU

120 also includes other suitable components (not shown), such as diffraction grating, light splitter, optical detector, and the like.

The collimator module **150** includes a collimator moving module configured to move the collimator **152**. In the FIG. **1** example, the collimator module **150** includes a collimator actuator **151** coupled with the collimator **152**. The collimator actuator **151** is configured to move the collimator **152** to one of a plurality of predetermined positions to suitably collimate the light beam. In an embodiment, a collimator position is predetermined in association with each data layer of a type of optical storage medium. In an example, a first collimator position C**1** is predetermined in association with the first layer L**1** of a type of the optical storage medium **101**, and a second collimator position C**0** is predetermined in association with the second layer L**0** of the type of optical storage medium **101**.

According to an aspect of the disclosure, because the collimator **152** only needs to be moved to the plurality of predetermined positions, the collimator actuator **151** can be implemented using a low cost actuator, such as memory metals, coils, and the like, to reduce a total cost of the electronic system **100**. Generally, an OPU uses a stepper motor having fine steps to precisely adjust a collimator position to compensate for, for example, layer thickness variation, lens optical property variation due to temperature variation, and the like, in order to reduce spherical aberration. In an example, the OPU uses a feedback loop to control the stepper motor to precisely move a collimator to an optimal position. This type of stepper motor can be costly.

According to an aspect of the disclosure, precise collimator position adjustment may not be necessary in some electronic systems. In an example, the electronic system **100** is a playback system, and the signal processing circuit **102** is implemented to have a relatively high error correction capability. Thus, the electronic system **100** has a relatively high tolerance of spherical aberration, and may not need precise collimator position adjustment. Then, in an example, a low cost stepper motor, such as a stepper motor having coarse steps can be used to move the collimator **152** to one of the plurality of predetermined positions. In another example, a low cost actuator, such as memory metals, coils, and the like, is used in the place of the stepper motor to reduce system cost.

The objective lens module **140** includes an objective lens actuator **141** and an objective lens **142** coupled together. The objective lens actuator **141** adjusts the objective lens **142** to focus the light beam at an appropriate layer of the optical storage medium **101**.

According to an aspect of the disclosure, the electronic system **100** is a playback system, and the OPU **120** is configured to generate an electrical signal responsive to information stored in the data layers of the optical storage medium **101**. Specifically, when the light beam is directed to a data layer, the light beam is reflected from the data layer. The reflected light beam has light properties corresponding to the information stored in the data layer. The OPU **120** includes a detector (not shown) configured to detect the light properties, and generates an electrical signal corresponding to the light properties. The electrical signal is provided to the signal processing circuit **102**. In an embodiment, the signal processing circuit **102** includes a read channel **103** to extract the information from the electrical signal.

The read channel **103** includes various circuits, such as analog circuits, digital circuits, and the like to process the received electrical signal. According to an aspect of the disclosure, the read channel **103** is configured to have an error tolerance. In an embodiment, when an error rate of the electrical signal is lower than a threshold (e.g., a bit-error-rate (BER) of the electrical signal is lower than a BER requirement), the read channel **103** can correctly extract the information from the electrical signal.

Further, according to an embodiment of the disclosure, the positions of the collimator **152** are predetermined such that the BER of the electrical signal is lower than the HER requirement. In an example, the position of the collimator **152** affects spherical aberration (SA) in the light beam. The spherical aberration then introduces bit errors. However, when the BER of the electrical signal is lower than the BER requirement, the read channel **103** performs appropriately, and can correct the errors.

The controller **130** is configured to provide control signals to the components in the OPU **120**, such as the collimator module **150** and the objective lens module **140**, and the like, to control the operations of the components, and coordinates the operations of the components. In an example, when the electronic system **100** decides to read the first layer L**1** of the optical storage medium **101**, the controller **130** sends control signals to the collimator actuator **151** to move the collimator **152** to the first position C**1** and sends control signals to the objective lens actuator **141** to adjust the objective lens **142** to focus the collimated light beam on the first layer L**1** of the optical storage medium **101**. Similarly, when the electronic system **100** decides to read the second layer L**0** of the optical storage medium **101**, the controller **130** sends control signals to the collimator actuator **151** to move the collimator **152** to the second position C**0**, and sends control signals to the objective lens actuator **141** to adjust the objective lens **142** to focus the collimated light beam on the second layer L**0** of the optical storage medium **101**. The controller **120** can be implemented by any suitable hardware/software. In an example, the controller **130** is implemented using suitable circuits, such as logic circuits, memory circuits, and the like. In another example, the controller **130** is implemented as a processor executing software instructions.

FIG. **2** shows a plot **200** of bit-error-rate (BER) characteristics according to an embodiment of the disclosure. X-axis is the position of the collimator **152**, and Y-axis is the BER of the electrical signal. The plot **200** includes a first curve **220** and a second curve **210**. The first curve **220** shows a first BER characteristic corresponding to reading data from the first layer L**1**, and the second curve **210** shows a second BER characteristic corresponding to reading data from the second layer L**0**.

As shown by the first curve **220**, when the collimator **152** is at an optimal position for the first layer L**1** that is optimized for reading data from the first layer L**1**, the electrical signal has the lowest BER. When the position shifts from the optimal position for the first layer L**1**, the BER of the electrical signal increases.

Similarly, when the collimator **152** is at an optimal position for the second layer L**0** that is optimized for reading data from the second layer L**0**, the electrical signal has the lowest BER. When the position shifts from the optimal position for the second layer L**0**, the BER of the electrical signal increases.

According to an embodiment of the disclosure, the BER characteristics are used to predetermine a plurality of positions for the collimator **152**. In an example, during manufacturing of the electronic system **100**, the BER characteristics are suitably determined. Further, a BER requirement, such as the BER requirement **230**, for the read channel **103** is determined. Based on the BER requirement, collimator positions in association with the data layers are determined.

In the FIG. **2** example, collimator position C**1** is selected for the first layer L**1** such that the BER of electrical signal generated responsive to reading from the first layer L**1** is

lower than the BER requirement **230**, and collimator position C**0** is selected for the second layer L**0** such that the BER of the electrical signal generated responsive to reading from the second layer L**0** is lower than the BER requirement **230**.

Then, the electronic system **100** is suitably manufactured according to the determined collimator positions C**1** and C**0**. For example, the collimator actuator **151** is then configured to be able to move the collimator **152** to the collimator positions C**1** and C**0**, and the controller **130** is configured to store control parameters that enable the operation of the collimator module **150**, and enable the coordination of the collimator module **150** with the other components of the OPU **120**.

It is noted that the collimator positions may need to satisfy other suitable requirement. In an example, the collimator positions C**1** and C**0** are selected such that the BERs of the electrical signal have suitable margins to the BER requirement **230**.

FIG. **3** shows a flow chart outlining a process example **300** for the electronic system **100** according to an embodiment of the disclosure. In an example, the electronic system **100** is a playback system that reads data stored on the multiple data layers of the optical storage medium **101**, and operates based on the data. The process starts at S**301** and proceeds to S**310**.

At S**310**, the controller **130** stores predetermined collimator positions in association with respective data layers. The collimator positions are pre-determined to ensure electrical signals generated from reading the respective data layers satisfy a BER requirement.

At S**320**, the controller **130** determines a target layer from a plurality of data layers. In an example, the controller **130** receives signals indicative of the target layer from other components, such as the processor **105** of the electronic system **100**.

At S**330**, the controller **130** provides control signals to the collimator actuator **151** to move the collimator **152** to a predetermined position in association with the target layer. In an example, based on the stored information and the target layer, the controller **130** determines the collimator position such that the electrical signal generated from reading the target layer satisfies the BER requirement. Then, the controller **130** provides the control signals to move the collimator **152** to the determined collimator position.

At S**340**, the controller **130** controls other OPU components to collectively focus a light beam onto the target layer to read the data stored on the target layer. In an example, the controller **130** controls the light source **121** to suitably emit a light beam. The light beam is collimated through the collimator **152**. Then, the controller **130** controls the objective lens module **140** to focus the collimated light beam onto the target layer. The controller **130** can also control a detector to detect reflected light beam and to generate an electrical signal responsive to the reflected light beam. The electrical signal is then provided to the signal processing circuit **102** for further processing. Then the process proceeds to S**399** and terminates.

It is noted that the process **300** can be suitably adjusted. In an example, the controller **130** provides the control signals to the collimator actuator **151** and the other OPU components at about the same time.

FIG. **4** shows a flow chart outlining a process example **400** according to an embodiment of the disclosure. In an example, the process **400** is performed during manufacturing of an electronic system **100**. The process starts at S**401**, and proceeds to S**410**.

At S**410**, a relationship is determined between electrical signal BER and collimator position for each of a plurality of data layers in an optical storage medium **101**, such as the first curve **220** and the second curve **210** in FIG. **2**.

At S**420**, a collimator position is determined for each of the plurality of data layers, such that an electrical signal generated responsive to reading information from the data layer satisfies a BER requirement. In an example, the BER requirement is determined based on error correction capability of a signal processing circuit. Then, based on the BER requirement and the relationship of BER with collimator position for a data layer, the collimator position for the data layer is determined.

At S**430**, a collimator of an electronic system is made movable to the determined collimator positions. In an example, a collimator actuator is configured to be able to move the collimator to the determined collimator positions.

At S**440**, the determined collimator positions are stored in association with the data layers in the electronic system **100**, such as in a controller **130**. Then, the process proceeds to S**499** and terminates.

It is noted that the process **400** can be suitably adjusted. In an example, the process **400** includes additional alternations to assemble various components of the electronic system **100** together.

While aspects of the present disclosure have been described in conjunction with the specific embodiments thereof that are proposed as examples, alternatives, modifications, and variations to the examples may be made. Accordingly, embodiments as set forth herein are intended to be illustrative and not limiting. There are changes that may be made without departing from the scope of the claims set forth below.

What is claimed is:

**1**. An apparatus, comprising:

a collimator configured to be moved between a plurality of predetermined discrete positions corresponding to a plurality of data layers of an optical storage medium, the discrete positions being determined without reference to a current optical storage medium being read; and

a controller configured to control the collimator to move between only the discrete positions to collimate a light beam, the collimated light beam being focused onto the corresponding date layer of the optical storage medium.

**2**. The apparatus of claim **1**, further comprising:

an objective lens configured to focus the collimated light beam onto the data layer of the current optical storage medium.

**3**. The apparatus of claim **1**, further comprising:

a collimator moving module configured to move the collimator to one of the plurality of positions responsive to a control signal from the controller.

**4**. The apparatus of claim **3**, wherein the collimator moving module includes at least one of memory metals, coils, and actuators.

**5**. The apparatus of claim **4**, wherein the collimator moving module is not a stepper motor.

**6**. The apparatus of claim **1**, wherein the predetermined discrete position associated with the data layer of the optical storage medium is predetermined based on an error rate requirement.

**7**. The apparatus of claim **1**, wherein the controller stores the discrete predetermined position associated with the data layer of the optical storage medium.

**8**. A method, comprising:

determining a target layer from a plurality of data layers of an optical storage medium;

moving a collimator to a predetermined position associated with the target layer; and

adjusting an objective lens to focus the collimated light beam onto the target layer of the optical disc;

wherein the predetermined position is one of two movable positions of the collimator that are determined without reference to a current optical storage medium being read.

**9**. The method of claim **8**, wherein moving the collimator to the predetermined position associated with the target layer further comprises:

moving the collimator to the predetermined position that is predetermined for the target layer to satisfy an error rate requirement.

**10**. The method of claim **8**, further comprising:

storing a plurality of predetermined positions associated with the plurality of data layers.

**11**. The method of claim **8**, wherein moving the collimator to the predetermined position associated with the target layer further comprises:

controlling at least one of memory metals, coils, and actuators to move the collimator.

**12**. A method, comprising:

predetermining a plurality of collimator positions associated with a plurality of data layers of an optical storage medium to satisfy an error rate requirement;

enabling a collimator moving module to move a collimator to the plurality of predetermined collimator positions; and

focusing a collimated light beam of the collimator onto a layer of the plurality of data layers of the optical storage medium;

wherein the collimator is configured to be only movable to the plurality of predetermined collimator positions associated with the plurality of data layers that are determined without reference to a current optical storage medium being read.

**13**. The method of claim **12**, further comprising:

characterizing a relationship of error rate and collimator position for each of the plurality of data layers; and

determining the collimator positions in association with the data layers based on relationships of error rate with collimator position.

**14**. The method of claim **12**, further comprising:

storing the predetermined collimator positions associated with the data layers in a controller that controls the collimator moving module.

**15**. An electronic system, comprising:

an optical pick-up unit (OPU) that includes

a collimator configured to have a plurality of predetermined discrete positions; and

a controller configured to control the collimator to move between the discrete positions to collimate a light beam, the collimated light beam being focused onto the data layer of the optical storage medium,

wherein the collimator is configured to be only movable to the predetermined position associated with the data layer that are determined without reference to the optical storage medium being read.

**16**. The electronic system of claim **15**, wherein the OPU further comprises:

a collimator moving module configured to move the collimator to one of the plurality of positions responsive to a control signal from the controller.

**17**. The electronic system of claim **15**, wherein the predetermined position associated with the data layer of the optical storage medium is predetermined based on an error rate requirement.

**18**. The electronic system of claim **15**, wherein the collimator moving module includes at least one of memory metals, coils, and actuators.

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